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AURORAL ELECTRON FLUXES.(U)  
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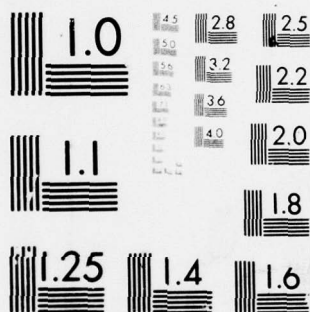
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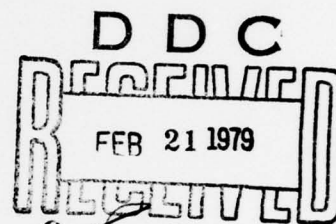
THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING  
Department of Atmospheric and Oceanic Science  
Space Physics Research Laboratory

FINAL REPORT

AURORAL ELECTRON FLUXES

William E. Sharp



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Air Force Office of Scientific Research  
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## INTRODUCTION

One of the goals of the research efforts being conducted by the group at Space Physics Research Laboratory is to arrive at an understanding of the energetics of the Earth's atmosphere. The atmosphere is bombarded by solar EUV photons and at high latitudes by energetic electrons. Both deposit energy in the atmosphere. The particular objective to which the research effort in this grant was directed was to analyze the electron energy distribution obtained on an auroral rocket flight AF10.312 to learn about the energy loss processes.

The achievement of this objective is approached by addressing four questions:

1. What is the energy distribution of the electron fluxes between a few tenths of an eV to tens of kilovolts at an instant of time?
2. How does this distribution vary with altitude?
3. What is the distribution in pitch angle of the different energy regions of the flux distribution, particularly for energies less than 100 eV?
4. How does the energy distribution change within a given auroral feature as well as with different manifestations of the auroral oval?

The instruments which obtained the data on the rocket flight are described in Technical Report AFCRL-TR-75-0023. Those instruments of particular interest in this report are the low energy electron spectrometer (HARP), the high energy electron spectrometer (ESA) and a group

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of high energy particle detectors which measured the total flux above a given energy threshold.

The rocket was launched along the geomagnetic meridian to the North during a negative magnetic bay. The payload crossed the Harang discontinuity (a demarcation between the positive bay and negative bay regions) and an auroral arc. The indication of the Harang discontinuity was a rotation in the direction of the electric field.

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## OBSERVATIONS

### Spectra

Four examples of the spectral distribution of the electron flux at a number of different altitudes are given in Figures 1 thru 4. These spectra exhibit features of flux spectra which have become well known in the last decade. However, smaller energy regions have generally been emphasized. There are volumes of data for the energy regions above 100 eV into the 10 KeV to 20 KeV region. There is much less data for the energy region 10 - 100 eV and only a handful for energies less than 10 eV. The data here represent the first available over such an extensive energy range (1 eV to 20KeV) at an instant of time and for a number of altitudes.

Examination of Figures 1 to 4 reveal two "bumps" in the flux distribution. One of these is at about 5 eV and the other is near 4 KeV. The dashed line in these figures is an extrapolation, generally necessary because of low signal on the instruments at these energies. The peak at 4 KeV is a monoenergetic beam which is incident on the top of the atmosphere. Above the depth of 150 km it is essentially unattenuated. The peak at 5 eV is due to the "secondary" electrons, which are produced in collisions between the primary electrons and the atmospheric gases. The peak is produced by the absence of a strong loss process for the electrons in this energy region. The primary loss process in this region is due to excitation of the metastable levels of atomic oxygen, [O]. Below 3 eV and above 7 eV excitation of vibrational levels and electronic levels of molecular nitrogen [N<sub>2</sub>], respectively, is occurring. Since at



altitudes below 200 km,  $N_2$  is the dominate species, stronger loss with respect to [O] would occur.

The general altitude behavior of the fluxes is to decrease in magnitude with decreasing altitude below 162 km. This is reasonable in light of the fact that the gas being penetrated is becoming more dense. This has the affect of reducing the primary flux as well as being a large loss for the "secondary" electrons produced in the ionizing events. Above 165 km the aurora changed character due to crossing the Harang discontinuity and altitude trend information is invalid. Other studies to higher altitudes (Sharp, et al., 1978) support the statements above.

Examination of the HARP spectra revealed no pitch angle dependance over 0 - 32 degrees. The fluxes measured by ESA showed some broadening of the peak region between 1 and 5 KeV and this was presumed to indicate some pitch angle dependance. The HARP and ESA were not set up on the payload to gather good pitch angle information.

### Spectrograms

Figure 5 is a three dimensional representation of the .7 KeV to 20 KeV electron fluxes as a function of energy and time (altitude). Examination of these fluxes indicate three types of auroral features traversed. The first is the weak steady precipitation encountered between 110 km and 165 km. Here the peak fluxes are centered at 2 KeV. The second region is the rapid increase in flux recorded at 165 km when crossing the Harang discontinuity. The increase amounted to an order of magnitude enhancement at energies less than 10 KeV. Figure 6 illustrates the flux spectrum at this time. Comparison of this spectrum with that of Figure 4 suggests that the largest increase in flux was between 500 eV and 4 KeV on a relative basis. The third region of interest is between 170 km and over apogee. An active arc (maybe series of arcs) was crossed. The characteristic signitive of an arc, the "inverted - V", is evident. The peak beam flux moves from near 2 KeV to about 7 KeV and then back to near 2 KeV. The high energy tail above the peak falls off much faster at high altitude than at low altitude. Figure 7 is a spectrogram for the low energy elctron fluxes. The order of magnitude increase in flux at 165 km is also evident here. The fluxes tend to remain high until the northern edge of the arc is being traversed whereupon the fluxes begin to diminish. An obvious feature of the data is the "bump" in flux at 5 eV. It remains pretty well defined throughout the flight. The rate of decrease of flux with increasing energy is not constant throughout the flight. Below 120 km for example, the flux decreases as  $1/E^2$  above 10 eV. Above 180 km the flux above 35 eV is decreasing as  $1/E$ .



Both the high energy electron flux and low energy electron flux are combined in the spectrogram shown in Figure 8. Examination of the figure reveals a couple of characteristics of the relative behavior of the fluxes, quite apart from what the particular auroral features are doing. Firstly, the flux magnitude for energies greater than 1 KeV changes more slowly as a function of altitude when compared with the flux magnitude for energies less than 1 KeV. Secondly, the slow changing character of the high energy flux is almost mirrored by the flux for energies less than 10 eV. The reason for this is that within both the high energy and very low energy regions there is structure. The structure may be being modified by wave-particle interaction which will produce changes in the 15 eV to 1 KeV region as well as the region less than 3 eV.

## CONCLUSIONS

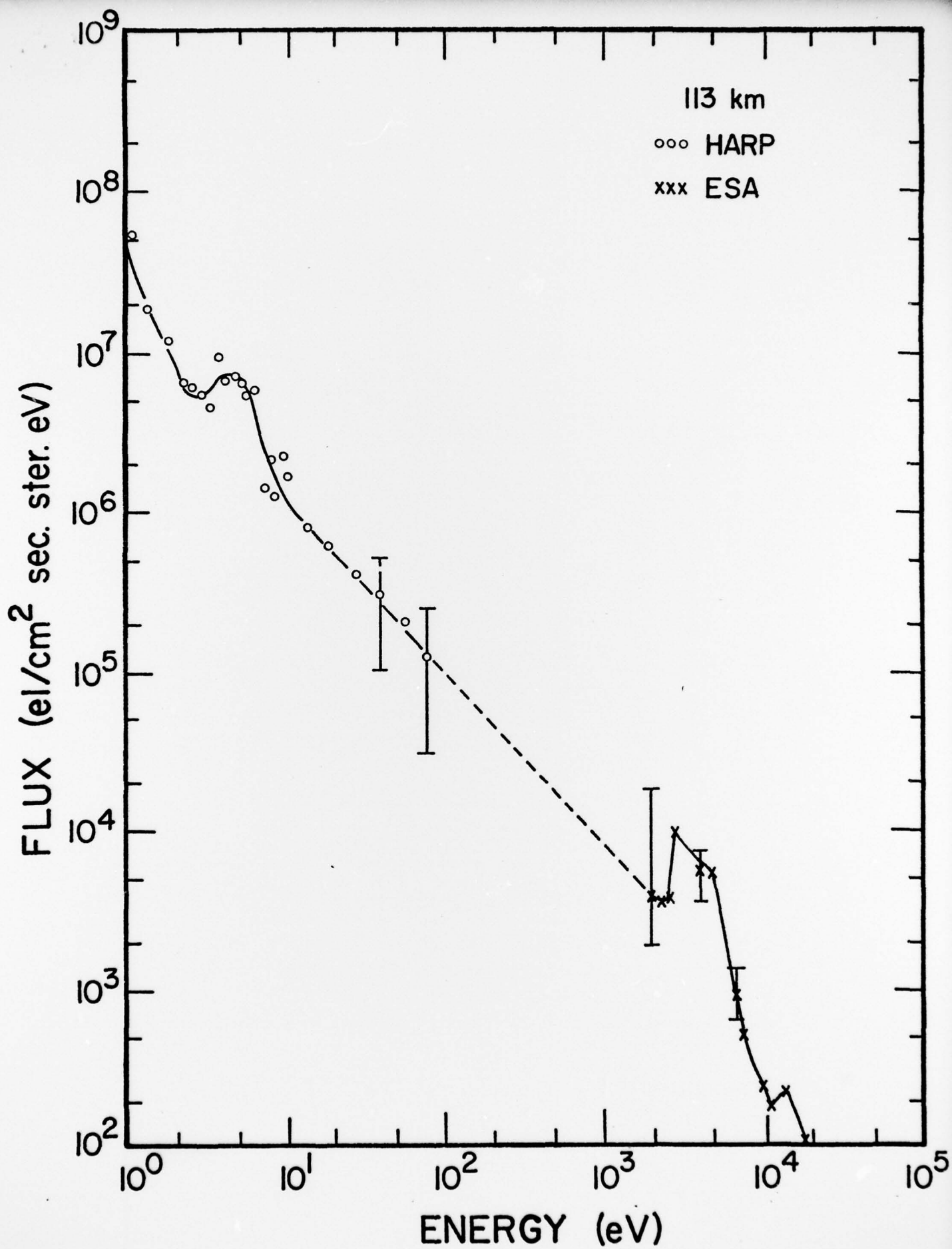
The electron flux measurements obtained by rocket AF10.312 as it traversed the aurora have presented the opportunity to have for the first time a complete electron flux-energy distribution at good resolution for energies between 1 eV and 30 KeV. These were obtained at an instant of time and over an altitude range of 110 km to 185 km. Two manifestations of the aurora were traversed: the Harang discontinuity and a bright arc. Within these features the spectral changes of the electron flux were obtained.

# BIBLIOGRAPHY

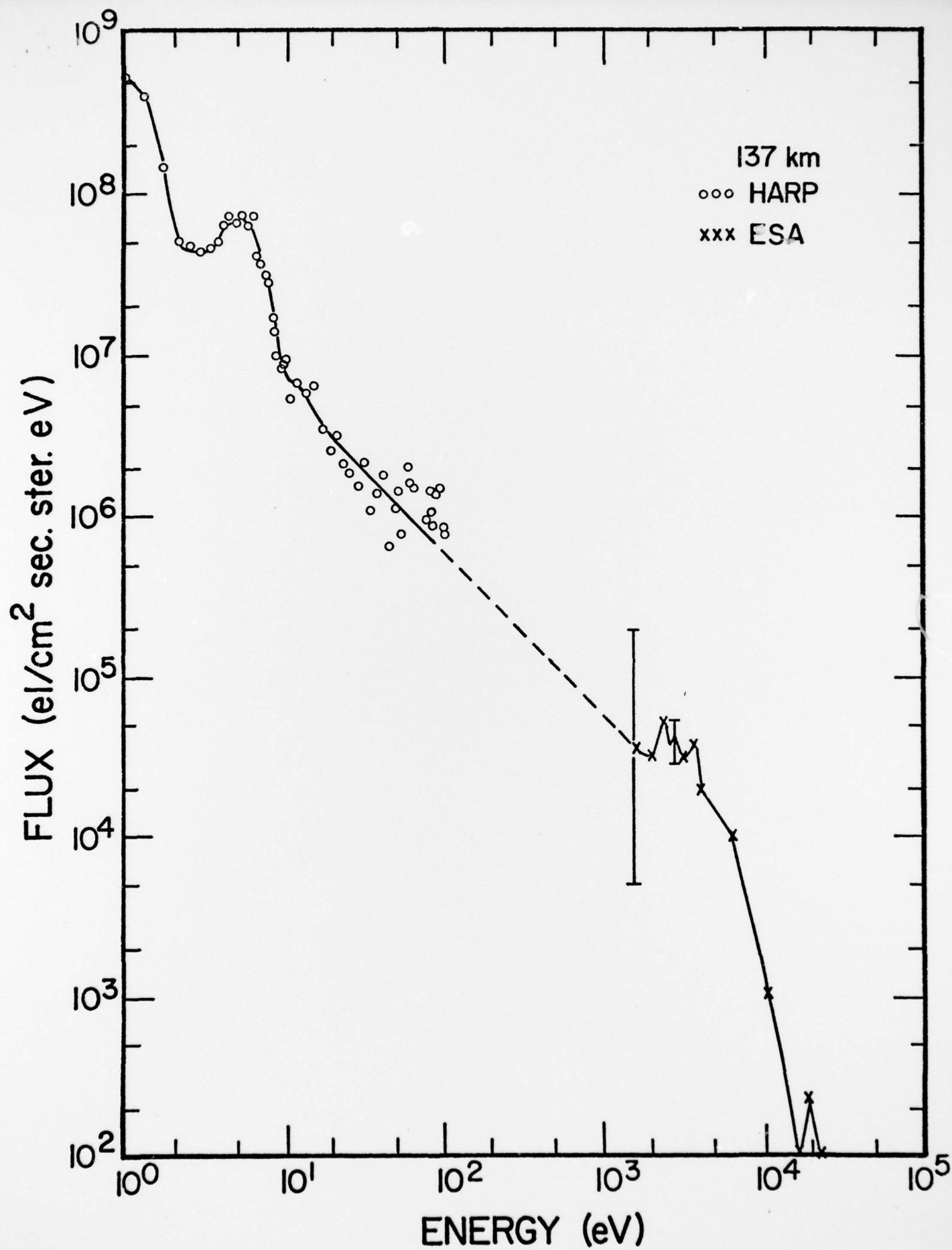
Sharp, W. E., M. H. Rees and A. I. Stewart, Coordinated rocket and satellite measurements of an auroral event: 2. The rocket observations and analysis, J. Geophys. Res., 85, , 1979.

#### FIGURE CAPTIONS

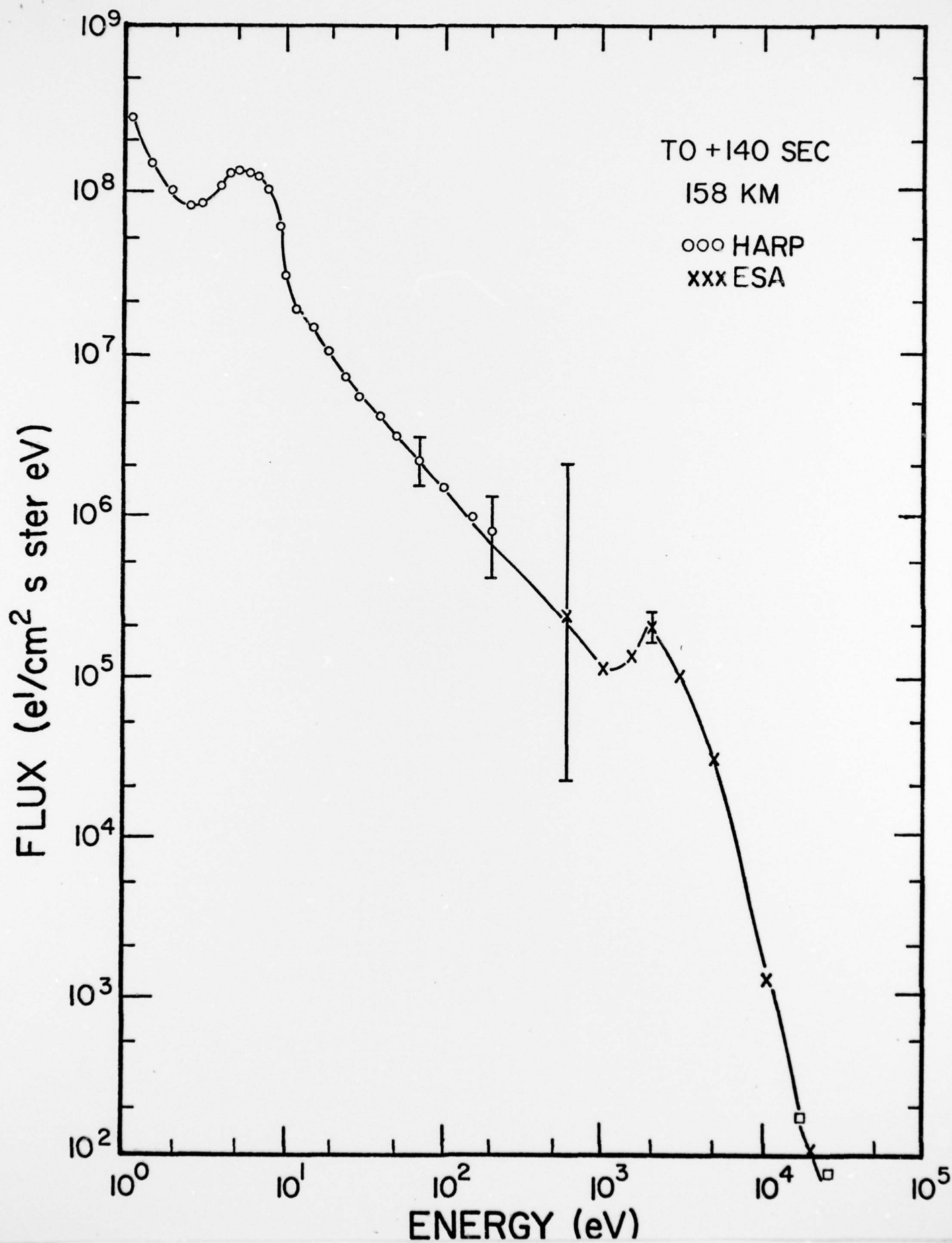
- Figure 1. Composite electron flux spectrum using the HARP data and the ESA data. The altitude is 113 km. The dashed line is an extrapolation over energies where the count rates of the detectors were below threshold. The vertical bars represent the statistics of the data.
- Figure 2. Same as Figure 1 but for 137 km.
- Figure 3. Same as Figure 1 but for 158 km.
- Figure 4. Same as Figure 1 but for 162 km.
- Figure 5. Spectrogram of the ESA data for the duration of the flight. The ordinate is energy, in this case KeV; the abscissa is altitude (time) in km. The magnitude of the flux is color coded according to the color bar at the right of the figure. Increasing flux moves toward red.
- Figure 6. Same as Figure 1 but for 165 km after flux increase.
- Figure 7. Same as Figure 5 but for HARP data.
- Figure 8. Same as Figure 5 but for composite of HARP and ESA data.

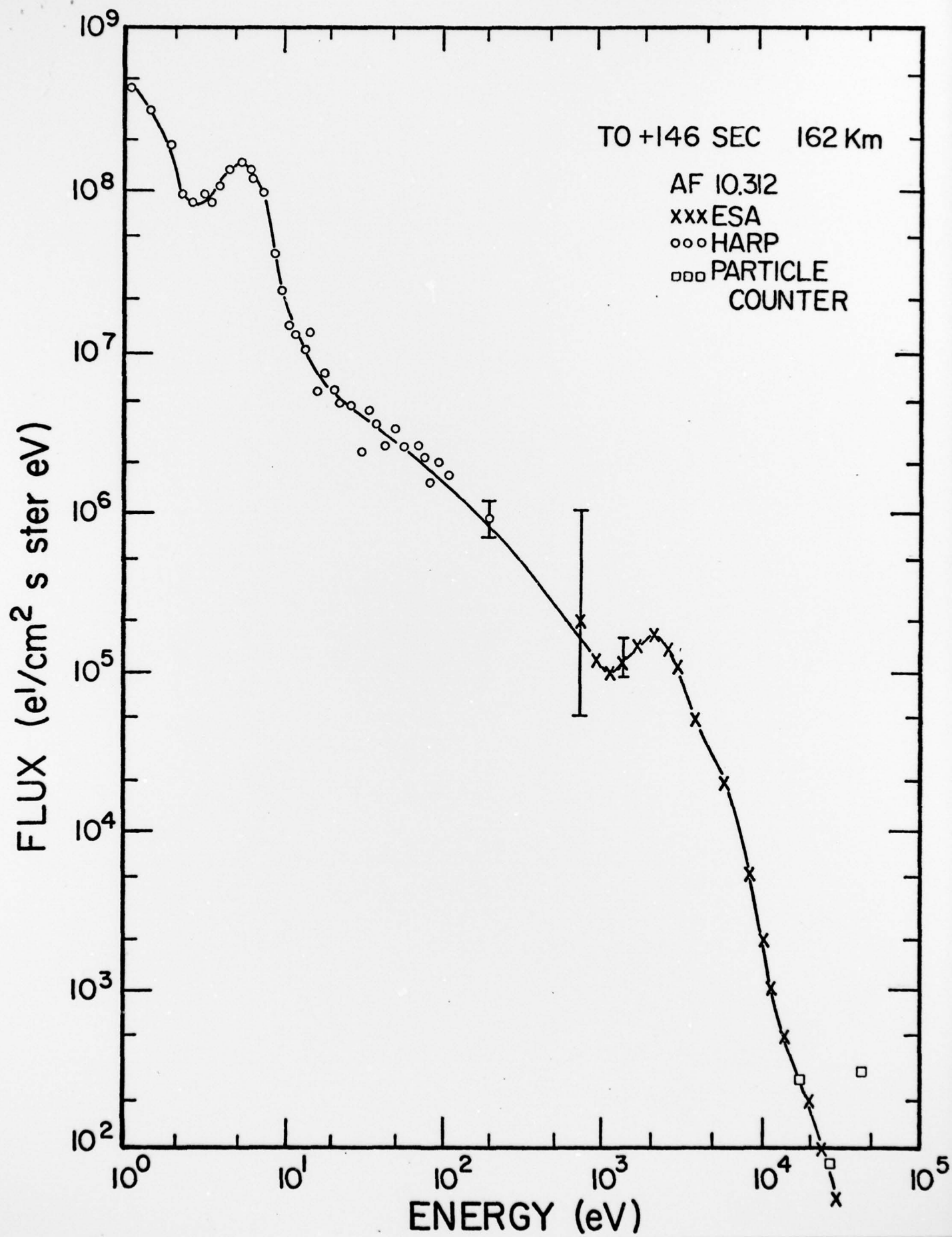


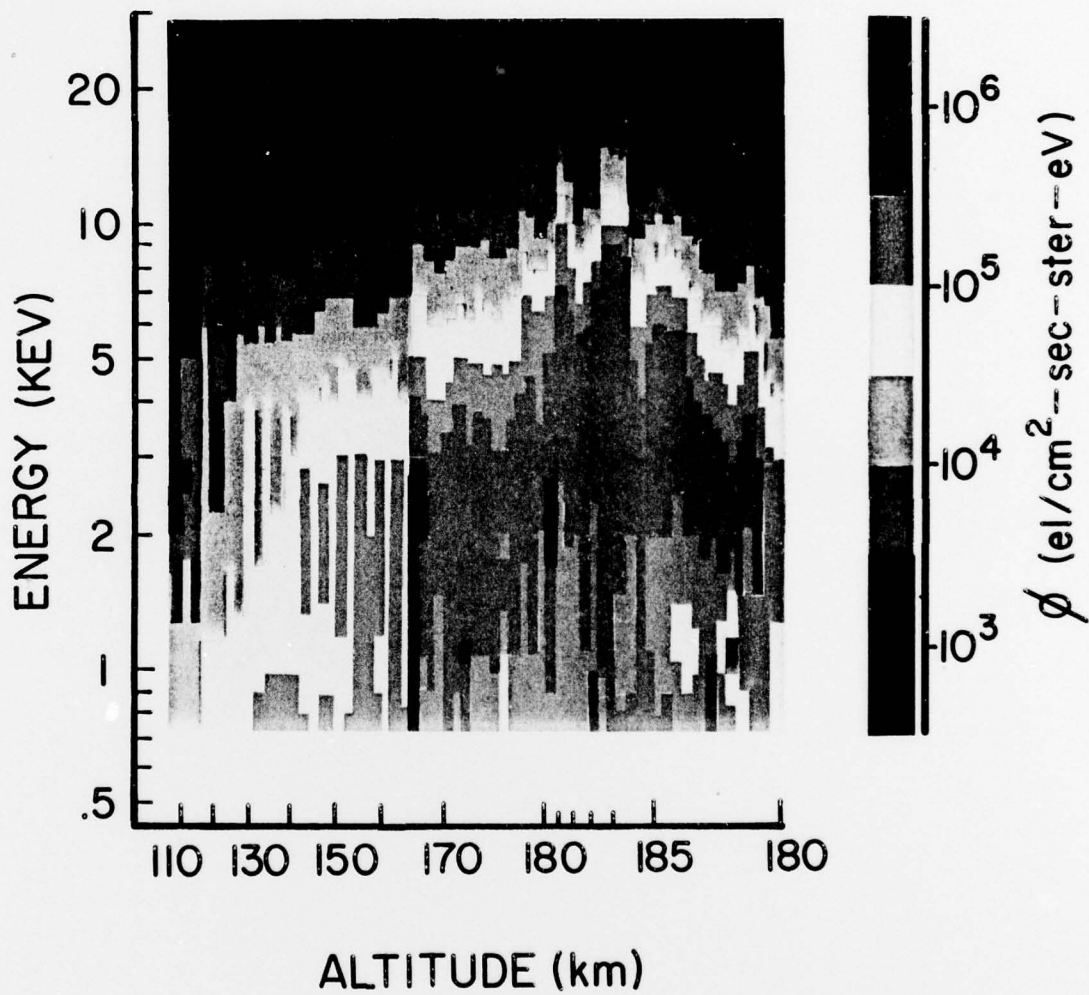


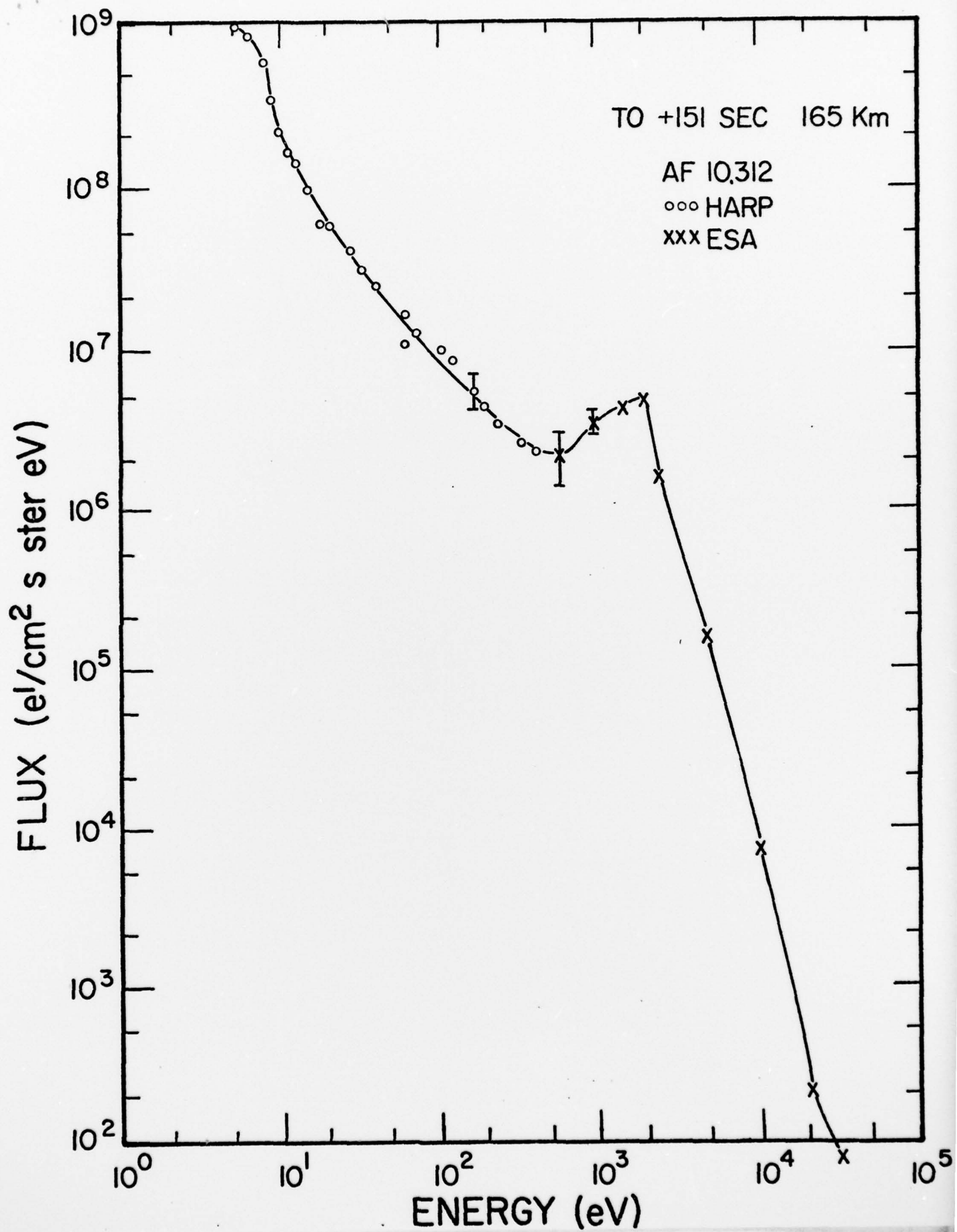




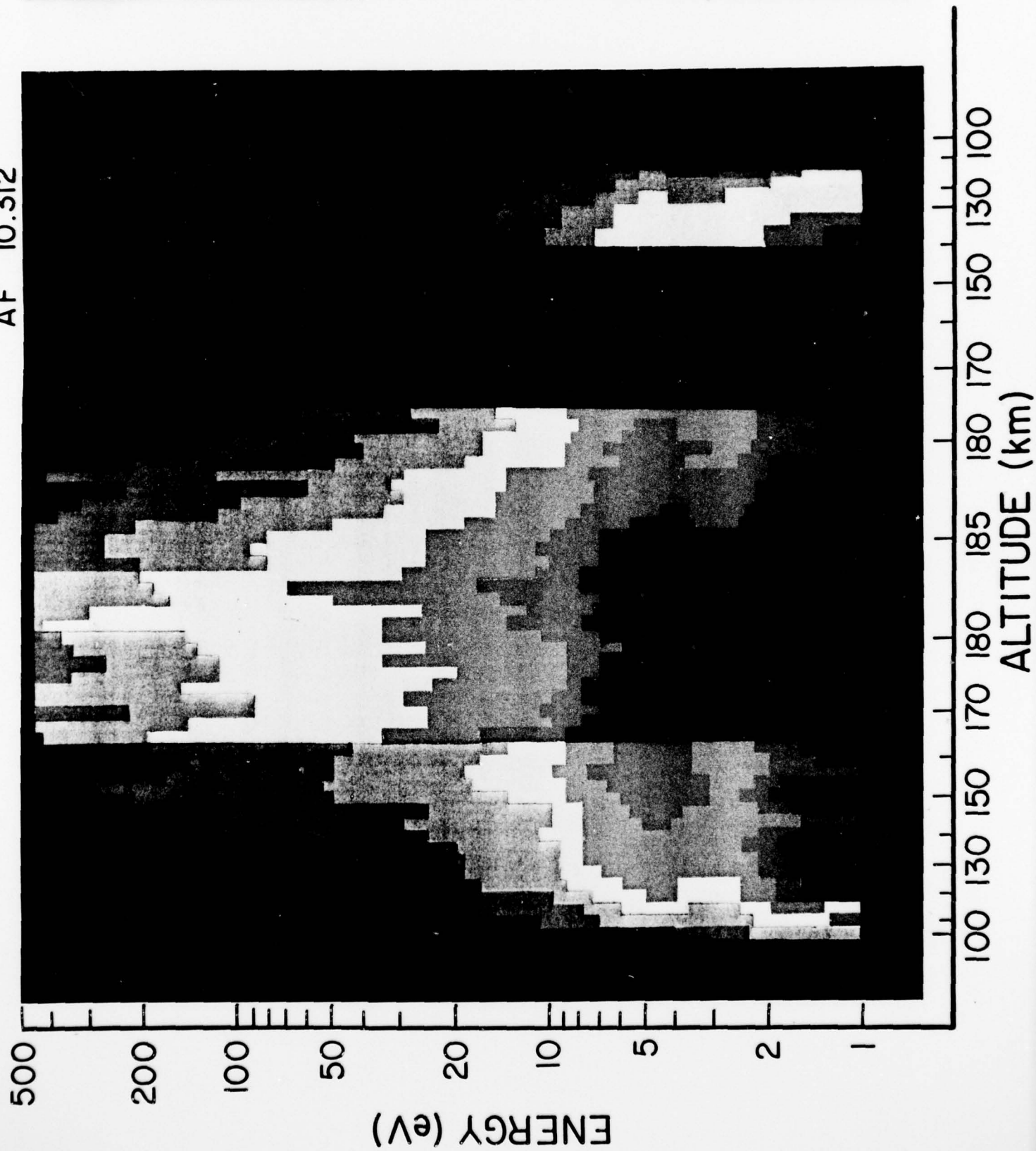




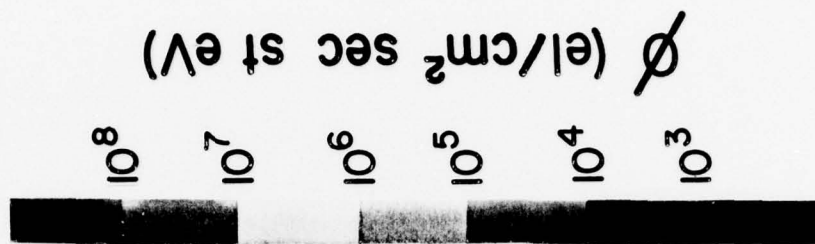
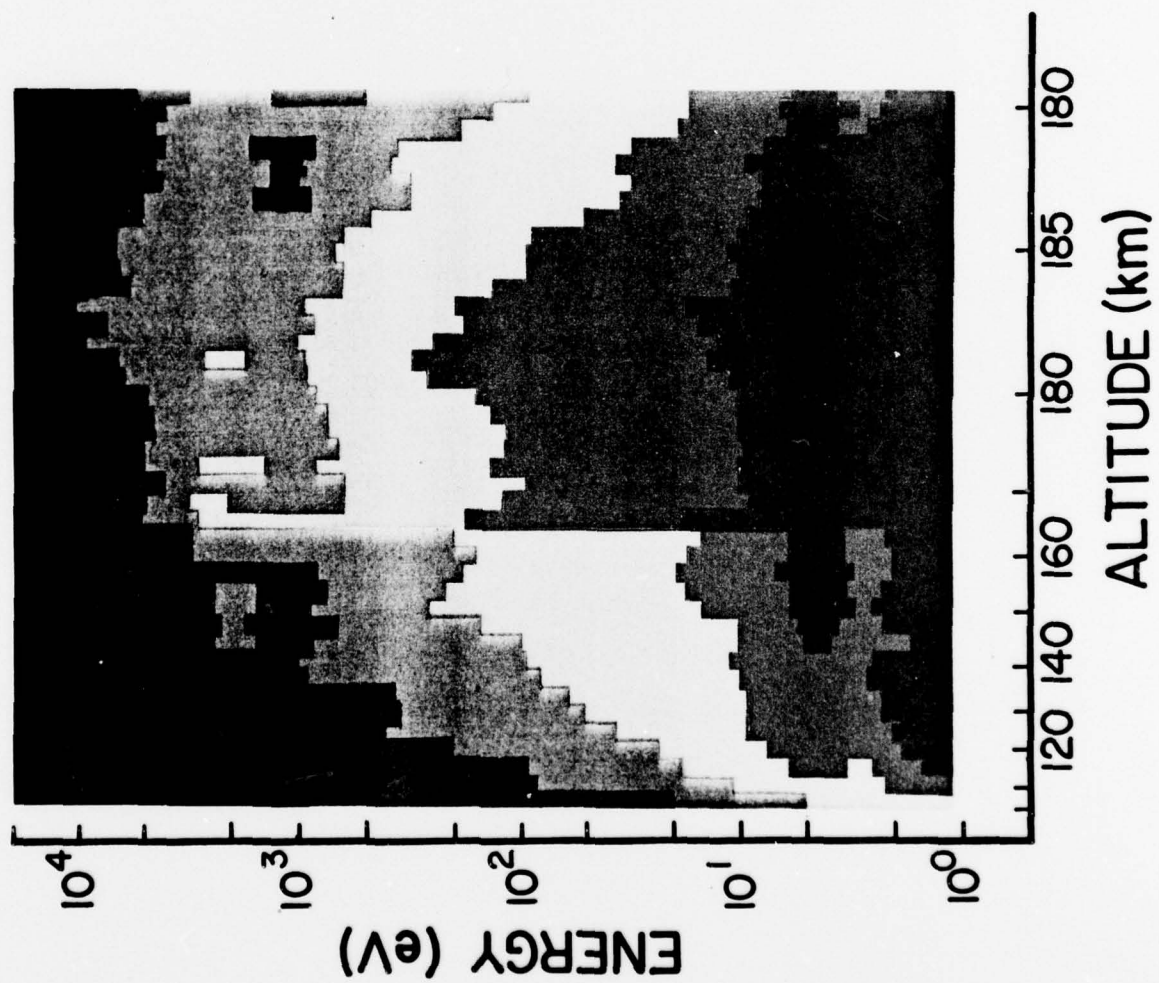




AF 10.312









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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  The data analyzed was from an auroral rocket probe, AF 10.312, launched in 1974 from Poker Flats, Alaska. The instrumentation is described in an AF Geophysics Laboratory Technical Report AFCRL-TR-75-0023. The data were from both a low energy and high energy electron spectrometer, which measured fluxes at 1-100 eV and 1-20 KeV respectively. The rocket flight was north along a geomagnetic meridian, crossing the Harang discontinuity and several non optical auroral arcs. Data represents the first available electron flux measurements over such an <div style="text-align: right;">(CONTINUED)</div>			

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20. ABSTRACT (Continued)

extensive energy range (1eV to 20 KeV) at an instant of time and for a number of altitudes. The flux distribution to the south of the discontinuity showed two 'bumps', one at 5eV and the other at 4KeV due to a lack of loss mechanisms at the lower energy and by the monoenergetic flux from space for the higher. The fluxes generally decreased with decreasing altitude as expected. No pitch angle dependence was discovered. South of the discontinuity peak fluxes were centered on 2KeV. An order of magnitude increase in flux at energies less than 10KeV were measured while the discontinuity was crossed (rocket was at 165 Km). In the auroral arcs, the peak flux was at 7KeV. Wave particle interactions were interpreted as the cause for the pattern of change with altitude of the greater than 1KeV and less than 10eV fluxes.

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